Rept
#3

No. 3

LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

PRICE $0.50

REPORT OF THE COMMITTEE ON MARINE ECOLOGY AS RELATED TO PALEONTOLOGY

1942 - 1943

HARRY S. LADD, Chairman

Presented at the Annual Meeting of the
Division of Geology and Geography
National Research Council
May 1, 1943

NATIONAL RESEARCH COUNCIL
2101 Constitution Avenue
Washington 25, D. C.

December 1943

(Reprinted February 1951)

NATIONAL RESEARCH COUNCIL

DIVISION OF GEOLOGY AND GEOGRAPHY

WASHINGTON, D. C.

* REPORT OF THE COMMITTEE ON MARINE ECOLOGY AS RELATED TO PALEONTOLOGY

May 1, 1943

Appendix Q of Annual Report
of the Division for 1942-1943

* (No. 3 in this Series)

(No. 1 - Report of Subcommittee on the Ecology of Marine Organisms, May 3, 1941)

(No. 2 - Report of Committee on Marine Ecology as Related to Paleontology, May 2, 1942)

COMMITTEE MEMBERS

Harry S. Ladd, Chairman

C. H. Edmondson	Roger Revelle
Gordon Gunter	F. W. Rolshausen
Remington Kellogg	H. C. Stetson
Kenneth E. Lohman	T. Wayland Vaughan

(First edition, December 1943)
(Reissued without change, February 1951)

CONTENTS

Page

Introduction 1

Bibliography of Paleoecology 1

Ecologic Data for Paleontologists 2

Current Activities 2

Eastern United States 2
Josiah Bridge 2
Marcus C. Old 2
Horace G. Richards 5

Middle United States 5
Willis G. Hewatt 5
Frank E. Lozo, Jr. 5
W. Armstrong Price and Gordon Gunter 5
F. W. Rolshausen 7
L. W. Stephensen 7

Western United States 7
Lore David 7
J. Wyatt Durham 7
Dennis L. Fox and Wesley R. Coe 7
J. Harlan Johnson 9
L. W. LeRoy 9
John Q. Burch and Thomas Burch 9

Outside the United States 9
M. L. Natland 9

Recently Published Papers 10

General 10
Plants 15
Protozoans 15
Coelenterates 17
Echinoderms 17
Mollusks 18
Arthropods 19
Vertebrates 20
Problematical Fossils 20
Miscellaneous Reports 21

Diatoms as Food of Oysters by Thurlow C. Nelson 23

Ecologic Relationships of Larger Foraminifera by Earl H. Myers 26

Tertiary and Cretaceous Paleontology of California Based on Fossil Fish Remains by Lore R. David 31

REPORT OF THE COMMITTEE ON

MARINE ECOLOGY AS RELATED TO PALEONTOLOGY

INTRODUCTION

During the past year the Committee's activities have been greatly restricted due to the fact that most of its members are either serving in the armed forces or are devoting part or all of their time to war work. Early in July 1942 the Chairman was transferred from Washington to Rolla, Missouri, and no regular meetings of the four Washington members were held. The Chairman has attempted to keep the program alive through correspondence and conferences with other Committee members. Serious consideration was given to the possibility of recessing the work of the Committee until after the war, but this was deemed inadvisable, the members feeling that it might be difficult to revive the program if work were stopped entirely. The brevity of the present report is a direct reflection of the general curtailment of ecologic work due to the war.

BIBLIOGRAPHY OF PALEOECOLOGY

In last year's report a plan for the preparation of an annotated bibliography of paleoecology was announced and first assignments were announced, as follows:

Hexactinellid Sponges -- Kenneth E. Caster
Scleractinia -- T. Wayland Vaughan and John W. Wells
Brachiopods -- G. Arthur Cooper
Diatoms -- Kenneth E. Lohman
Problematical fossils -- Kenneth E. Caster
Mollusca of the Tertiary of northeast Mexico,)
Eocene of Rio Grande Embayment,) -- Julia Gardner
Claiborne of east Gulf region)

During the current year additional assignments have been made, as follows:

Algae — J. Harlan Johnson
Nautiloid Cephalopods -- H. B. Stenzel
Fishes -- Lore David
Marine Mammals -- Remington Kellogg
Conodonts -- Samuel Ellison
Lower Ordovician -- James S. Cullison
Tertiary of Texas (exclusive of Eocene of Rio Grande Embayment) -- H. B. Stenzel
Marine Tertiary of California (exclusive of Foraminifera) -- W. P. Woodring
Quaternary Sediments of the Atlantic and Gulf Coastal Plains -- H. S. Ladd

Most of those who have accepted assignments are engaged in war work, and it is doubtful if much progress will be made during the war period.

ECOLOGICAL DATA FOR PALEONTOLOGISTS

It is recognized that many paleontologists who are interested in paleoecological studies need a greater knowledge of present day ecology. Much of the ecological work that has been done and is being done with living organisms has only a very indirect bearing on paleontological work, but other studies furnish much information that is of great value to paleontologists. The reports of the Committee attempt to cite current references of this kind, but there is a very large amount of ecological data, much of it published many years ago, in journals and other biological publications, not seen by many paleontologists. A systematic review of this literature by biologists who are well aware of the type of material useful to paleontologists would be very worth while. An investigation of this sort was first suggested by Dr. H. B. Stenzel. The Committee feels that it would be justified in initiating a second bibliographic program to concentrate the specialized data needed for paleoecological studies from the voluminous literature of biology. This work will be started during the fall of 1943.

CURRENT ACTIVITIES

EASTERN UNITED STATES

Josiah Bridge of the U. S. Geological Survey has been working out faunal relationships in the Upper Cambrian of Tennessee. Similar studies, made in Alabama in collaboration with Preston E. Cloud and Norman L. Benson, indicate that lateral intergradations of lithologic types can be recognized across the Appalachian Valley. Interpretations and correlations based on this evidence give a unified picture of depositional conditions in the Appalachian geosyncline. The stratigraphic sequence appears less complicated than previously supposed.

Professor Marcus C. Old of Hofstra College, Hempstead, N.Y. presented a paper on Boring Sponges at the meeting of the National Shellfisheries Association in Philadelphia, June 1942. In this paper he summarized his observations and studies made, for the most part, in Chesapeake Bay with the support of the Chesapeake Biological Laboratory at Solomons Island, Maryland, as follows:

"Oystermen long have recognized the conspicuous yellow to orange growths on the surface and in the shells of various mollusks especially oysters. Some seasons the incidence of infestation of shells in certain areas seemed very high and occasionally the infestation appeared to be great enough to cause virtually the destruction of every live oyster. Thus this boring sponge came to be associated with the sudden or gradual depletion of formerly prolific oyster beds and slowly there arose a realization of the necessity of knowing the boring sponge better. The summer work at the Chesapeake Biological Laboratory concentrated on the taxonomy and distribution

of this sponge in the Chesapeake Bay area, and occasionally collections were made or received from other isolated areas along the Atlantic Coast.

"From these studies on taxonomy it appears that there are at least seven species of boring sponges that must be considered. The former habit of simply referring to the boring sponges as Cliona sulphurea or Cliona celata is in error. In fact the name sulphurea is not even valid for it is identical to the older species celata described in 1826 from collections in Scotland. This Cliona celata seems to have a world wide distribution in strictly marine waters. Two other species, one originally described from collections off Scotland and in the English Channel along the French Coast, and another originally from the coast of India and later found to have a wide European distribution, also seem to be common in the marine waters along our coast. Three of the species appear to be distinct from previously described specimens, and one of these is characteristic of brackish waters. One other specimen along the Atlantic Coast was not studied by us but appears in the collections from the Dry Tortugas, off Florida, studied by de Laubenfels.

"On opening sponge-riddled oysters and removing the meat it is very common to find perforations penetrating through the inner face of one or both valves. Often a fresh white deposit of calcium carbonate may conceal older openings, at the same time showing distinctly fresh tiny openings. Ordinarily, it would seem, the oyster can handily control this interference of its immediate environment between the mantle and the shell. Another complement of inner surface perforations may easily be found in the muscle scar. These openings at the attachments of the muscle fibers must interfere with the facility of contraction and the maintenance of contraction of the adductor muscle. One riddled oyster specimen with naturally gaping valves showed a soft discolored muscle mass and perforations at the shell attachment. These sponges like others draw water into their gastral or digestion chambers by way of the tiny surface pores and expell it by larger surface pores. In the metabolic process waste products are eliminated in the excurrent flow of water. If these tunnels of the sponge open on the inner surface of an oyster shell it seems that fluids of the oyster must be drawn into the sponge body by the incurrent flow and, at the same time, some waste materials of the sponge must be deposited in the spaces between the mantle and shell or between muscle fibers and shell. One or both of these processes conceivably could take place. Also it appears sound to believe that because of continuous external and internal openings in the shell, the oyster is not able to control the immediate environment surrounding its mantles or body. These factors probably are responsible as the chief causes of the mortality of the oyster since it would bring about 1) a reduction of body fluids 2) contact with toxic wastes and 3) disease by the introduction of parasitic microorganisms from the sea water.

"The boring sponge is easily cultured or kept alive in the laboratory. The easiest method is to place a clean infested shell in a finger bowl with just enough sea water to cover the shell. A daily complete change of water is not necessary. The sponge remains active and continually ejects tiny fragments of calcium carbonate. If you place one of these cultures under a binocular microscope, you can readily find the osculum of an excurrent canal

and see that at regular intervals there is spewed, with considerable force, a particle of shell.

"In a twenty-four hour interval many small piles of these particles will have collected on the bottom of the dish and on the surface of the shell. Looking at these tiny particles through the compound microscope you see many angulated fragments. The concave surfaces, sharp angles and striations give one the impression that they could be the result of a mechanical action, a cutting action of one or more kinds of spicules. If you place thin pieces of transparent calcite among infested oysters and suspend the container in sea-water, you will find, in time, a setting of the boring sponge on the calcite. Many pieces of calcite will illustrate a diminutive sponge just beginning to sink itself into the calcium carbonate. You look at this and into the young sponge settled in the slight pit through the microscope, Leitz Ultrapak with vertical illumination using a magnification of 3-5 hundred One can readily see etched outlines in the calcite about the sponge corresponding to the particles spewed by an active sponge in an oyster shell. Many of these tiny sponges show no spicules whatever so you realize that the cleavage of these particles is apparently not due to a mechanical action.

"In examining pieces of shell from the walls of caverns made by the boring sponge in shell, you frequently find that boring fungi are also present. In some shells these filaments of the fungi become numerous forming a reticulate structure. And it seems logical to suppose that a more complex reticulate structure of interconnecting and crossing fungi filaments could produce a separation of tiny lime particles. But here again an hypothesis of a symbiotic relationship between a rock fungus and a sponge is questionable, probably far-fetched, since many other pieces of shell from the walls of caverns do not reveal any evidence of a fungus.

"Chitinous sheets found between layers of calcium carbonate in shells also become perforated by a gradual removal of tiny pieces corresponding in form to the expelled particles or fragments of shells. This, according to some arguments, seems to be a point against another hypothesis which holds that the boring action is due to an acid secretion. On the other hand, analyses of sea-water containing active boring sponges in otherwise clean shells did show a slight daily increase in dissolved calcium.

"Boring sponges, like other sponges, reproduce asexually and sexually. In the Chespaeake Bay at Solomons we found eggs within the sponge beginning about August 1st. Clean pieces of shell or calcite received a set of larvae as early as July 28th. European investigators have found eggs as early as March and as late as October in various species. The young individual bores very actively and as it spreads new individuals branch or bud from the original. By the approach of unfavorable conditions, a mass of sponge consisting of hundreds of individuals, produced as the result of budding, has penetrated the confines of the shell. Activities as measured by the ejection of shell particles slacken and stop, and at this time gemmules, internal buds consisting each of many primitive cells, may be found in pockets at the end of a tunnel in the oyster shell. Gemmules frequently are found also during the active season. They are naked bodies without spicules.

"Boring sponge eggs are ejected into the sea-water apparently soon after fertilization. The fertilized egg proceeds through the usual 2 cell, 4 cell, 8 cell, etc. embryo stages gradually forming a typical sponge larva, a ciliated parenchymula, which is an active swimmer. It finally settles on its anterior end, becomes flattened, the interior cells migrate to the external surface and form the epithelium and mesenchyme, and the flagellated cells are thus enclosed and become the choanocytes that line the digestion cavities. A large central cavity appears, incurrent pores and an excurrent osculum break through, spicules are secreted, and a few days later a complete adult sponge has been formed.

"..... so far very little has been accomplished especially as to the effects of the boring sponge on shellfish culture. Now that identifications seem to have been completed, and one may know definitely with which species he is working, the time seems ripe for concentrated work on the life-cycle and environmental relationships of this sponge....."

Dr. Horace G. Richards of the Academy of Natural Sciences of Philadelphia states that since September 1, 1942 he has been engaged in a study of mollusks and other fossils from wells drilled on the coastal plain from New Jersey to Florida. His final report will contain a discussion of certain aspects of paleoecology as revealed by his study of the fossils.

MIDDLE UNITED STATES

Professor Willis G. Hevatt of Texas Christian University is carrying on a study of the shallow-water fauna of the Gulf of Mexico although handicapped by transportation problems and other restrictions of war time.

Frank E. Lozo, Jr. of the Department of Geology, Texas Christian University, has completed his paper on "Biostratigraphic Studies of Some North Texas Trinity and Fredericksburg Foraminifera"; it will be published in an early number of the American Midland Naturalist. Mr. Lozo is now studying shallow-water Foraminifera from the Lower Cretaceous of central Texas and Foraminifera and Ostracoda from the Lower Cretaceous of Mexico.

Dr. W. Armstrong Price, of Corpus Christi, Texas, and Gordon Gunter of the Texas Game, Fish and Oyster Commission, have recently collected information to be published in the Proceedings and Transactions of the Texas Academy of Science under the title of "Certain Recent Geological and Biological Changes in South Texas, with Consideration of Probable Causes". Geological changes on the land and changes in the flora and fauna have taken place at the same time as heavy silting and filling of the Laguna Madre and certain estuaries.

Some perennial streams of the eastern Reynosa Cuesta, South Texas, dried up about 1870 and since then have flowed only intermittently. Silting of an isolated estuary, the Callo del Oso, was first noted between 1870 and 1890, prior to cultivation but not prior to grazing in the region. There is some evidence suggesting that inner segments of coastal bays also

have been silting more rapidly in recent years.

Padre Island, the southernmost barrier island of the Texas Coast is said to have been green until shortly after 1870 when it became greatly denuded of vegetation and the fauna changed. Extremely rapid filling of the coastal lagoon, Laguna Madre, has taken place since the first maps were made in 1881, chiefly by sand from Padre Island carried into the Laguna by hurricanes and the southeast winds and presumably at an increased rate since denudation of the island. The record rains of 1941 and the heavy precipitation of 1942 have restored much of the grass cover of the northern half of the island--that least disturbed by the numerous hurricane tides of the past decade.

The Laguna Madre is the most prolific fishing area of Texas and is of particular interest because it becomes over-salty during dry years, the salinity becoming almost three times that of sea water in some instances, and the animal life within it dies. There is practically no drainage into the Laguna. Today the area of shallow flats is increasing and in the future the high evaporation rate of water, which becomes very warm in the shallow areas, can be expected to bring about over-saline conditions more rapidly and thus more often. Since 1880 a large strip from the middle Laguna has become dry land covered with only an inch or two of water at the very highest tides.

Filling of the Laguna Madre is not an isolated phenomena. There are not specific data at hand to establish the rate of filling over a century, but there seems to have been an acceleration since 1880, at the same time as other geological and biological changes. It is concluded that the disappearance of much of the native vegetation of Padre Island accelerated the rate of filling of Laguna Madre by sediments and that the incidence of droughts combined with the activities of grazing animals were partly responsible for desertic conditions on the island between 1830 and 1941.

Century-old live oak trees and many mesquites were killed in South Texas in the early 1880's. Since 1870 mesquite, chaparral and other thorny brush from the Southwest has covered the coastal prairie northward and eastward from the Nueces River to Karankawa Bay,-and also areas eastward to the San Bernard River-and within the memory of living men, hundreds of thousands of acres of tall grass prairie have been transformed into brush jungles.

The coati mundi has in recent years become established in southern New Mexico and Arizona and there are indications that it may be invading Texas. The roadrunner has spread eastward in recent years to East Texas and has recently been seen in Louisiana. The armadillo has spread from the "land of cacti and horned toads" to points east of the Mississippi River, covering a distance of 400 miles or more in fifty years. There are indications that other elements of the biota are spreading northward and eastward. Contrary migrations in the region have not been observed or reported.

It is concluded that these changes were brought about by farming, draining, grazing and other influences of the white settlers, coupled with a series of hard droughts in South Texas beginning in the 1880's.

F. W. Rolshausen of the Humble Oil and Refining Company states that studies of bottom samples obtained from the Gulf of Mexico near the mouth of the Rio Grande are being carried on and that S. W. Lowman of the Shell Company is working on Gulf samples from the mouth of the Mississippi River and from an area lying east of the Mississippi delta.

Dr. L. W. Stephenson of the U. S. Geological Survey plans to continue his study of the Lewisville member of the Upper Cretaceous Woodbine formation in Texas. The Lewisville, as pointed out by Dr. Stephenson, is a shallow water facies whose fauna differs from that of the Comanche below and from that of the Eagle Ford above.

WESTERN UNITED STATES

Dr. Lore David of the California Institute of Technology, who has contributed a special article on fossil fish remains to the present report, states that a general paper on "The use of fossil fish scales in micro-paleontology" is being printed by the Carnegie Institution of Washington. Dr. David is now finishing reports on the Cretaceous and Eocene scales of California which will also be published by the Carnegie Institution.

The paper by J. Wyatt Durham, entitled "Corals from the Gulf of California and the North Pacific Coast of America", mentioned in last year's report of this Committee has been submitted for publication. (An abstract entitled "Recent Pacific Coast Coral Faunas" was published in the Bulletin of the Geol. Soc. Amer. vol. 53, p. 1835, 1942.)

Dr. Denis L. Fox of the Scripps Institution of Oceanography and Wesley R. Coe have prepared two papers on the California sea-mussel. One of these has already been published [Coe, Wesley R. and Fox, Denis L., Biology of the California sea-mussel (Mytilus californicus), I. Influence of temperature, food supply, sex and age on the rate of growth, Jour. Exp. Zool., vol. 90, No. 1, pp. 1-30, 1942], the manuscript of the other having been completed on April 10 of this year [Fox, Denis L. and Coe, Wesley R., Biology of the California sea-mussel (Mytilus californicus) II, Nutrition, metabolism, growth and calcium deposition]. A summary of these two papers prepared by Dr. Fox is as follows:

"The California mussel is a mucus feeder, obtaining its food by secreting sheets of mucus over the gills; in this mucus all the micro-organisms and detritus particles drawn by ciliary action into the mantle cavity are collected or adsorbed and are then carried either to the mouth or ejected from the mantle cavity as pseudofeces. By this means the mussel is able to obtain from the water much finer particles and colloidal substances than many other filter-feeding invertebrates.

"Growth is greatly accelerated during the third month of age, length increasing by two-thirds, and volume, tissue-weight and shell-weight four-fold. Ratios of length, volume, dry-weight of tissue and weight of shell respectively in 1, 2 and 3 year mussels are as follows: length, 80 : 120 : 145 mm., volume, 35 : 111 : 180 cc., dry-weight of tissues, 2 : 5.6 : 8 gr., and shell-weight, 23.5 : 70 : 104.5 gr., giving linear double-logarithmic

relationships between length and each of the other properties.

"Rate of growth is dependent upon supplies of finely divided organic detritus, zoospores, floating gametes, nannoplankton and other microplankton (with special reference to dinoflagellates) utilized as food. There seems to be a generally positive correlation between water-temperature and growth rate, but with a decrease in the month of highest temperature. During two of the three years there was a generally positive correlation between growth rate and abundance of dinoflagellates.

"Growth rate is retarded in mussels living on rocks exposed to the pounding surf and to longer periods out of water between tides. These animals possess thicker, heavier shells relative to length than the narrower, thinner-shelled phenotype found on the pilings of the pier.

"Very young mussels of about 10 mm. length possess a slightly lower tissue-water content than the larger animals (78% vs. 83%) and nearly six-fold the concentration of tissue calcium (1.12% vs. 0.2%). Ash content is variable, with an average of about 11%. Shells are close to 93% $CaCO_3$, with small amounts of organic matter, especially in the periostracum.

"Full, ripe gonads weigh as much or more than the somatic tissues, and contain about 44% protein (dry weight) and from 6 to 10% lipoids (sperm and eggs respectively).

"Mussels depend upon materials present as finely divided detritus for more than four-fifths of their nutrition, living microplankton occupying a subordinate position of importance as direct food.

"Computations show that the mussel's removal of organic matter and oxygen from the sea and its fixation of organic matter as somatic and gametic tissue are balanced by its return of gametes, CO_2 and feces to the sea. Thirty-five per cent of the intake is oxidized; 4 per cent is fixed as gametic and somatic tissues, while the remaining 61 per cent is unassimilated. The importance of bacteria and other microplankton in the fixing of soluble nutrients is emphasized.

"Unfed mussels in the aquarium may lose, in 6 months time, 80% of their tissue-weight, but sustain no loss of shell substance.

"The mussel's supply of calcium for shell-building is not available in sufficient quantity in the food but must be obtained from the water either in particulate or soluble form. Calcareous particles are ingested in large quantities. Slightly acidic conditions in the stomach and digestive diverticulum would favor the dissolution of the $CaCO_3$, while the mildly alkaline nature of the mantle next the shell permits calcium deposition by that tissue.

"Increase in size or weight was not obtained by various artificial foods nor by the addition of chalk to the water; a generous natural diet in the aquarium, with abundant aeration resulted in a moderate growth.

"The mussel affects the physical properties of its environment by removing from the water all minute suspended objects and particles, both organic and inorganic, which enter its inhalent aperture, thus altering the turbidity and light-penetration of the water and, through the deposition of feces and pseudofeces, the character of the bottom. It alters the chemical composition of the water slightly by removing dissolved oxygen and releasing carbon dioxide and nitrogenous excretory products. By its own death or that of its gametes, it adds to the temporary supply of protein, lipid and carbohydrate matter. In its biological effects it removes phytoplankton, including bacteria, also minute zooplankton, contributing in turn to the food supply of saprophytic and algal life by supplying catabolites, and to the nutriment of various predatory animals, including echinoderms, crustaceans, mollusks, fishes and birds. Through its gametes and free-swimming larvae it contributes directly or indirectly to the food supply of all the associated invertebrates in the vicinity and of many species of fishes."

Prof. J. Harlan Johnson of the Colorado School of Mines has reported that his manuscript on the calcareous algae and associated organisms from the Leadville (Mississippian) limestone of central Colorado is completed. Work on a report on Pennsylvanian and Lower Permian calcareous algae and algae limestone from Kansas is being continued. The report discusses the relation of algae deposits to cyclotherms of deposition.

Mr. L. W. LeRoy of the Colorado School of Mines has recently completed a paper on the Pleistocene and Pliocene ostracode fauna of the Coastal region of southern California. This work represents the first published data on California ostracodes since 1896.

John Q. Burch and Thomas Burch, according to Professor Hubert G. Schenck, have carried on detailed collecting of living mollusks off Redondo Beach and Monterey Bay, California. They have issued preliminary check lists in the minutes of the Conchological Club of Southern California. The list based on material from off Redondo Beach has been revised by the Messrs. Burch and is to be incorporated in a paper that Prof. Schenck and Miss Myra Keen have completed on the use of molluscan assemblages for ecologic inferences.

OUTSIDE THE UNITED STATES

M. L. Natland of the Richfield Oil Corporation, Long Beach, California, states that his work on a large number of bottom samples collected off South America has been halted, probably for the duration of the war. A chart showing the bathymetric ranges of the Foraminifera and other microscopic organisms has, however, been prepared and should anyone desire a rough copy of this chart it can be furnished with little trouble.

RECENTLY PUBLISHED PAPERS

GENERAL

Dapples, E. C., The effect of macro-organisms upon near-shore marine sediments, Jour. Sed. Petrology, vol. 12, pp. 118-126, 1942.

Dietz, R. S., Emery, K. O. and Shepard, Francis P., Phosphorite deposits on the sea floor off Southern California, Geol. Soc. Amer., Bull., vol. 53, pp. 815-848, 1942.

Dunbar, M. J., Marine macroplankton from the Canadian eastern Arctic, II, Medusae, Siphonophora, Ctenophora, Pteropoda and Chaetognatha, Canadian Jour. Res., Sec. D, Zool. Sci., vol. 20, pp. 71-77, 1942.

Goldring, Winifred and Flower, Rousseau H., Restudy of the Schoharie and Esopus formations in New York State, Amer. Jour. Sci., vol. 240, pp. 673-694, 1942.

Gunter, Gordon, Offatts Bayou, a locality with recurrent summer mortality of marine organisms, Amer. Midland Nat., vol. 28, pp. 631-633, 1942.

Hadding, Assar, The Pre-Quaternary rocks of Sweden, VI, Reef limestone, pp. 1-137, Meddelanden från Lunds Geologisk-Mineralogiska Institution, Lunds Universitets Årsskrift, N. F., Avd. 2, bd. 37, nr. 10, 1941. (Reviewed by W. H. Twenhofel, Jour. Sed. Petrology, vol. 12, pp. 139-1940, 1942).

Harvey, H. W., Production of life in the sea, Biol. Reviews Cambridge Phil. Soc., vol. 17, pp. 221-246, 1942.

Imlay, Ralph W., Evidence for Upper Jurassic landmass in eastern Mexico, Bull. Amer. Assoc. Petrol. Geol., vol. 27, pp. 524-538, 1943.

Lindman, Raymond L., The trophic-dynamic aspect of ecology. Ecology, vol. 23, pp. 399-418, 1942.

Lowenstam, Heinz A., Facies relation and origin of some Niagaran cherts, (abst.). Geol. Soc. Amer., Bull., vol. 53, pp. 1805-1806, 1942.

Lowenstam, Heinz A., Geology of the eastern Nazareth Mountains, Palestine, Cretaceous Stratigraphy, Jour. Geol., vol. 50, pp. 813-845, 1942.

Matoda, S., Comparison of the conditions of water in the bay, lagoon, and open sea in Palao, Palao Trop. Biol. Sta. Stud., vol. 2, pp. 41-48, 1940.

McDougall, Kenneth Dougal, Sessile marine invertebrates at Beaufort, North Carolina, Duke University Marine Station, Bull. No. 1, 1943. (Reprinted from Ecol. Mon., vol. 13, pp. 321-374, 1943).

Payne, Thomas G., Stratigraphical analysis and environmental reconstruction, Bull. Amer. Assoc. Petrol. Geol., vol. 26, pp. 1697-1770, 1942.

Pearse, A. S., Humm, H. J. and Wharton, G. W., Ecology of sand beaches at Beaufort, N. C., Ecol. Mon., vol. 12, pp. 135-190, 1942.

The sand beach at Beaufort, North Carolina, was studied for two summers, specimens being taken with many kinds of gear.

Marine littoral sands at Beaufort swarm with plant and animal life. Many species show peculiar adaptations for existence in a medium that is continually rearranged, that is deficient in oxygen and contains much CO_2. Data on pore size, temperature, salinity, oxygen and humus content, and pH of the beach are presented.

An abundatn microfauna lives down to depths of 3-5 cm. Nematodes, copepods, Foraminifera, polychaetes, burrowing amphipods, and young clams are the chief components. The microfauna collects around organic remains. Lepidopa, Emerita, Aranaeus, Donax, Ogyris, and Chirodotea are characteristic of sand beaches of the open ocean. On sand-flats in sounds there are many clams, annelids, heart urchins, and crustaceans which do not occur along the open sea.

There is a tendency for beach animals to segregate into definite zones. Zonation from the high tide mark to below the low tide line is shown for many animals, a number of which have hard parts. Donax, Chirodotea and Emerita are typically intertidal, while the sand dollar, Mellita,was found to be most abundant immediately below the lowtide mark. This paper compares the fauna of the sea beach with that of bays and sand-flats and the offshore waters. All the permanent macrofauna of beaches are burrowers and are modified and equipped for burrowing in a number of ways. Some merely bury themselves while others live in more or less permanent holes.

The life history of a typical sand beach animal, the mole crab, Emerita talpoida (Say), is described. The action of bacteria and microscopic algae are discussed. Use of bacterial culture methods indicate that one-celled algae are probably more significant in the economy of the beach than previously supposed. A list of animals found on the beaches at Beaufort, N.C. is appended. (Gordon Gunter.)

Pettersson, Hans, Swedish Oceanographic Research in 1941, Science, vol. 96, pp. 156-157, 1942.

Raymond, Percy E., The pigment in black and red sediments, Amer. Jour. Sci., vol. 240, pp. 658-669, 1942.

Richards, H. C. and Hill, Dorothy, Great Barrier Reef bores, 1926 and 1937, Descriptions, analyses, and interpretations. Reports of the Great Barrier Reef Committee, vol. 5, pp. 1-122, Government Printer, Brisbane, Australia, 1942.

Realizing that it was essential to know the physical and chemical make-up and the thickness of the reef and that it was likewise essential to study the non-coral reef foundation, the Committee decided upon a drilling program.

Holes were put down on Michaelmas Cay and Heron Island. These sites are 700 miles apart, one at about the central point in the length of the reef, the other at the southern end of the reef. The authors state that the sites were located as near to the outer edge of the reef as it was practicable to conduct drilling operations; the points chosen lie 14 and 10 miles from the seaward margin of the barrier. The Michaelmas Cay hole was carried to a depth of 600 feet, the one on Heron Island to 732 feet. Both passed through several hundred feet of coralliferous limestone into quartz-foraminiferal sand, but neither reached the basement rock.

A calyx type of drill was used on both holes and only a small fraction of one percent of core was recovered from the footage drilled below 20 feet. Core is recovered with difficulty in porous material, particularly if a calyx type of drill is used, for the shot used in drilling run into the cavities and are lost.

The cores and cuttings from the two Barrier Reef holes were very carefully studied and are described in detail. However, along with this factual material there are interpretations with which all readers will not agree. Indeed, interpretations of the Australian cuttings may differ as widely as have those based on the famous drilling on Funafuti.

On page 67 in commenting on the age of the deposits penetrated under Heron Island, as indicated by a study of the corals, the authors are conservative but following this they state:

"The deductions on depth of formation of the reef rock that one may draw from the corals are perhaps more satisfactory. Thus the fact that they are all reef forms indicates that the surface of the forming reef rock was never at a greater depth than 25 or 30 fathoms. This is clearly substantiated by Iredale's work on the mollusca."

The reviewer would like to point out that the fact that only reef forms were identified does not necessarily indicate shallow water deposition unless the corals clearly are in positions of growth. The reef forms may have been transported down a talus slope from shallow water to deeper water. Likewise, the fact that all of the mollusks identified by Iredale from the Heron Island hole are reef forms does not establish the deduction (p. 68) that there has been a subsidence of at least 100 fathoms in recent times. Likewise open to criticism is the statement (p. 72) that the reef rock penetrated on Heron Island must have been laid down at depths of less than 25 fathoms. Sample No. 41 from a depth of 445 to 465 feet, for example, includes material called Reef Rock yet most of it is a soft limestone with sandy and

muddy detritus. The samples from this interval contained no trace of corals or mollusks but they did show numerous Foraminifera. According to Cushman (page 114 in an appendix to the same report) these were a mixture of worn and broken large, shallow water species and smaller well preserved deeper water species.

It appears to the reviewer that drilling into sea-level or into elevated reefs will not yield conclusive evidence as to their origin unless a good percentage of core is recovered. With such a recovery of large diameter cores (preferably BX, 1 5/8 inches or NX, 2 1/8 inches) it would be possible to differentiate between transported material and reef rock made up of corals and algae in position of growth. Evidence of this sort might be decisive, at least as far as some coral reef theories are concerned. (H. S. Ladd)

Schenck, Hubert G. and White, Robert T., Collecting microfossils, Amer. Mid. Nat., vol. 28, pp. 424-450, 1942.

Stephenson, T. A., et al, A symposium on intertidal zonation of animals and plants.

(1) Stephenson, T. A., The causes of the vertical and horizontal distribution of organisms between tidemarks in South Africa, Proc. Linnean Soc. London, 154th Session (1941-42), Pt. 3, pp. 219-232, 1943.

The author summarizes his finds as follows:

"We have little hesitation in concluding that the principal agent responsible for the horizontal distribution of organisms round the South African coast is sea-temperature, that a subsidiary effect may be produced by the distribution of nutrient salts, and that no other of the factors involved has more than local effects, except in so far as it may cooperate in a minor degree with the broad variations in sea-temperature.

"In connection with zonation on the open rock (as distinct from that in pools and shaded places) we conclude that the controllers of primary importance are the degree of exposure to the desiccation-heat-light complex acting together with the degree of exposure to wave-action. Contributing effects are undoubtedly produced by feeding habits, competition for food and space, and perhaps also by the percentage of time during which plants can utilize nutrient salts. Local effects can be produced by other factors, such as nature of the rock-formation and proximity of the rock to sand. Rock-formation acts primarily through its effects on degree of exposure to wave-action and distribution of shade.

"The zonation in rock-pools is apparently subject to a different combination of controls from that of open rock. Here the leading factors appear to be variations in temperature and salinity with contributory effects (at present difficult to estimate) from other causes.

Local effects are very powerful in the case of pools; and selective factors are probably only markedly effective at the higher levels. The populations of pools are affected by degree of exposure to wave-action and by others of the factors controlling distribution on open rock, as well as by the variations peculiar to pools.

"Light, as a primary cause of distribution, is probably more generally effective in determining the segregation of shade-loving from surface species than in contributing to the actual zonation, though it sometimes affects the latter also, especially locally.

"Although the importance of particular factors has been stressed in these paragraphs, it is clear from the information available that almost every factor whose influence between tidemarks can be imagined is able to produce some effect on zonation, even if this effect is not more than local in its results, or not more than contributory to other effects in its action."

(2) Colman, John, Some intertidal enigmas, Proc. Linnean Soc.London, 154th Session (1941-42), Pt. 3, pp. 232-234, 1943.

(3) Delf, E. Marion, The significance of the exposure factor in relation to zonation, Proc. Linnean Soc. London, 154th Session (1941-42), Pt. 3, pp. 234-239, 1943.

(4) Chapman, V. J., Zonation of marine algae on the sea-shore, Proc. Linnean Soc. London, 154th Session (1941-42), Pt. 3, pp. 239-253, 1943.

Stephenson, W., An ecological survey of a beach on the Island of Raasay, Proc. Univ. Durham Phil. Soc., vol. 10, pp. 332-357, 1942.

Sverdrup, H. W., Johnson, M. W., and Fleming, R. H., The oceans: their physics, chemistry, and general biology, pp. x + 1087, 1942.

Teichert, Curt, The Devonian of Western Australia, A Preliminary Review, Amer. Jour. Sci., vol. 241, pp. 69-94; 167-184, 1943.

Watkin, E. E., The macrofauna of the intertidal sand of Kames Bay, Millport, Buteshire, Trans. Roy. Soc. Edinburgh, vol. 60, pt. 2, pp. 543-561, 1942.

Young, Frederick Plentz, Jr., Black River stratigraphy and faunas, Part 1, Amer. Jour. Sci., vol. 241, pp. 141-166, 1943.

Zobell, Claude E., Changes produced by micro-organisms in sediments after deposition, Jour. Sed. Petrology, vol. 12, pp. 127-136, 1942.

PLANTS

Chapman, V. J., An introduction to the study of algae, pp. x + 387, Cambridge (University Press) 1941; New York (Macmillan Co.).

Conger, Paul S., Accumulation of diatomaceous deposits, Jour. Sed. Petrology, vol. 12, pp. 55-66, 1942.

Davis, John H., Jr., The ecology of the vegetation and topography of the Sand Keys of Florida, Papers from the Tortugas Laboratory, vol. 33, pp. 113-195, Carnegie Inst. Washington Publication 524, 1942.

Johnson, J. Harlan, The geologic importance of calcareous algae with annotated bibliography, Quart. Colorado School of Mines, vol. 38, no. 1, pp. 102, 1943.

After discussing the historical and distributional data concerning the fossil calcareous algae, the author presents the main portion of his paper, namely, a bibliography on fossil algae. Most of the papers cited have been abstracted. (Roland W. Brown).

Purer, Edith A., Plant ecology of the coastal salt marshlands of San Diego County, Calif., Ecol. Mon., vol. 12, pp. 81-111, 1942.

According to variation in salinity and the differences in aeration, 60 marsh species are distributed throughout the area.

Scottsberg, C., Communities of marine algae in subantarctic and Antarctic waters, K. Swenska Vetenskapsakad. Handl. 19, pp. 1-92, 1941.

ZoBell, Claude E. and Feltham, Catherine B., The bacterial flora of a marine mud flat as an ecological factor, Ecology, vol. 23, pp. 69-78,1942.

Water of a shallow bay in California contains several thousand to a few million bacteria per cc. and the bottom, often exposed, contains many millions of bacteria per gram. Bacteria occur in mud at depths far below where other organisms are found. At certain places bacteria create conditions inimical to other forms of life but more generally they are beneficial to animal life by serving as food and by mineralizing organic matter.

PROTOZOANS

Adams, Bradford C., Suggestions for using Foraminifera in zonal paleontology, Amer. Midland Naturalist, vol. 29, pp. 137-146, 1943 (originally published Proc. Sixth Pac. Sci. Cong., vol. 2, pp. 665-670).

Allen, W. E., Occurrences of "Red Water" near San Diego, Science, vol. 96, p. 471, 1942.

Clark, Bruce L. and Campbell, Arthur S., Eocene radiolarian faunas from the Mt. Diablo area, California, Geol. Soc. Amer., Spl. Paper No. 39, pp. 1-112, 1942.

Cushman, Joseph A., A report on samples obtained by the boring at Heron Island, Great Barrier Reef, Australia, Repts. of the Great Barrier Reeef Committee, vol. 5, Appendix 1, pp. 112-119, Govt. Printer, Brisbane, 1942.

In the summary the following interesting observations appear:

"In some of the samples there is a peculiar assemblage consisting of larger, shallow waterforaminifera, usually much worn and broken, accompanied by numerous smaller and well preserved specimens of species known to be characteristic of deeper waters. This is similar to conditions found to-day about many of the coral islands of the Pacific where species known to live in very shallow depths may be found mixed with deeper assemblages. In such assemblages the shallow water specimens are invariably broken or worn and represent beach or reef material washed out by wave and current action into deeper water. In such cases far greater weight is given to the deeper water, well preserved specimens in determining the living fauna at that depth."

The author cites the exact horizons where such mixed assemblages occur in the boring at Heron Island. He concludes that there must have been decided changes in sea level but adequate evidence for such changes is not presented.

Myers, Earl H., Biology of the Foraminifera and their significance in paleoecology, New York Acad. Sci., Trans., vol. 4, no. 6, 1942.

Myers, Earl H., Rate at which Foraminifera are contributed to marine sediments, Jour. Sed. Petrology, vol. 12, pp. 92-95, 1942.

Myers, Earl H., Biology, ecology, and morphogenesis of a pelagic Foraminfer, Stanford Univ. Pub., Univ. Ser. Biol. Sci., vol. 9, no. 1, 1943.

Phleger, F. B., Foraminifera of submarine cores from the Continental Slope, Part 2, Bull. Geol. Soc. America, vol. 53, pp. 1073-1098, 1943.

Vaughan, T. W., Eocene largerForaminifera from Barbados, British West Indies, and a catalogue of the American species of the Discocyclinidae (Abst.), Geol. Soc. Amer. Bull., vol. 53, pp. 1811-1812, 1942.

Woolnough, W. G., Geological extrapolation and pseudo-abyssal sediments, Bull. Amer. Assoc. Petrol. Geol., vol. 26, pp. 765-792, 1942.

Includes a discussion of the environment of certain radiolaria-bearing beds.

COELENTERATES

Cooper, Chalmer L., North American Chitinozoa, (Abst.), Geol. Soc. Amer., Bull., vol. 53, p. 1828, 1942.

Manton, S. W., On two new species of the Hydroid Myriothela, British Museum (Nat. Hist.), British Graham Land Exped. 1934-37, Sci. Repts., vol. 1, pp. 255-294, 1940.

Vaughan, Thomas Wayland and Wells, John West, Revision of the suborders, families, and genera of the Scleractinia, Geol. Soc. Amer., Spl. Paper 44, 1943.

In this paper there ia a rather full discussion of the ecology of corals, pp. 52-69. The topics are as follows:

Relation of corals to environment

- Depth of water
- Water Temperature
- Hermatypic corals
- Ahermatypic corals
- Salinity
- Air
- Light
- Food
- Situation
- Sediment

Growth rate

Relation of corals to other animals and to plants

- Animals
- Plants

Distribution of corals by ocean currents

Summary of ecology

More than 1,000 selected references to the literature on the Scleractinia are given of which numbers 169-247 deal with ecology and distribution.

Wells, John W., Scleractinian corals from the Eocene Upper Scotland formation of Barbados and the Miocene of Martinique (Abst.), Geol. Soc. Amer., vol. 53, p. 1812, 1942.

ECHINODERMS

Howe, H. V., Neglected Gulf Coast Tertiary microfossils, Bull. Amer. Assoc. Petrol. Geol., vol. 26, pp. 1188-1199, 1942.

Contains a discussion of the environment and occurrence of ophiurians, comatulids, starfish, and holothurians.

Lowenstam, Heinz A., Morphological response of Ancyrocrinus to environmental changes, (Abst.), Geol. Soc. Amer., Bull., vol. 53, p. 1832, 1942.

Yamanouti, T., Ecological and physiological studies on the holothurians in the coral reef of Palao Island, Palao Trop. Biol. Sta. Stud., vol. 1, pp. 603-635, 1939.

MOLLUSKS

Dexter, Ralph W., Notes on the marine mollusks of Cape Ann, Massachusetts, Nautilus, vol. 56, no. 2, pp. 57-61, 1942.

Edmondson, Charles H., Teredinidae of Hawaii, Bernice P. Bishop Museum, Occ. Papers, vol. 17, pp. 97-150, 1942.

Gunter, Gordon, Seasonal condition of Texas oysters, Proc. and Trans. Texas Acad. Sci., vol. 25, pp. 89-93, 1942.

Iredale, Tom, Report on molluscan content of Heron Island Reef boring samples, Repts. of the Great Barrier Reef Committee, vol. 5, Appendix 1, pp. 120-122, Govt. Printer, Brisbane, 1942.

A examination of molluscan fossils from the drill hole revealed no evidence of any save littoral species. Because the fossils were found at several horizons from the surface to a depth of 696 feet, the author concludes that there have been three or four submergences.

The author has little hesitation in regarding all of the fossils as of recent age, stating that the specimens from the first 60 feet are indistinguishable from shells collected on the beach today. The boring mollusks from a depth of 500 feet are represented by "casts" only, but as the associated barnacles are "in the fresh state of recent specimens" the author concludes that the mollusks too must be recent.

Many of the molluscan shells are reported as fragments but it is not clear from the report whether the breakage is due to the drilling operations or to erosion prior to deposition. The author does not mention the possibility that littoral molluscan shells may have been carried beyond the littoral zone before being deposited. The fact that the fossils are indistinguishable from those on the beach today does not necessarily indicate a recent age. Many Tertiary mollusks from the Pacific fall into this category, some shells retaining strong traces of their original color pattern. (H. S. Ladd).

Iredale, Tom and Allan, Joyce, A review of the relationships of the mollusca of Lord Howe Island, Australian Zoologist, vol. 9, pt. 4, pp. 444-451, 1940.

Keen, A. Myra, Viability of a marine snail, Nautilus, vol. 56, no. 1, pp. 34-35, 1942.

Keen, A. Myra and Doty, Charlotte L., An annotated check list of the gastropods of Cape Arago, Oregon, Oregon State Monographs, Studies in Zool., no. 3, pp. 1-16, 1942.

Newell, Norman D., Late Paleozoic pelecypods, part II, Mytilacea, pp. 1-115, 15 pls., 1942.

Reinhart, Phillip W., Mesozoic and Cenozoic Arcidae from the Pacific Slope of North America, Geol. Soc. America, Spl. Paper No. 47, 1943.

Richards, Horace G. and Harbison, Anne, Miocene invertebrate fauna of New Jersey, Proc. Acad. Nat. Sci. Philadelphia, vol. 94, pp. 167-250, 1942.

Richards, Horace G., Pleistocene mollusks from Margarita Island, Venezuela, Jour. Paleo., vol. 17, pp. 120-123, 1943.

Richards, Horace G., Pliocene and Pleistocene mollusks from the Santee-Cooper area, South Carolina, Notulae Naturae, Acad. Nat. Sci. Philadelphia, no. 118, pp. 1-7, 1943.

ARTHROPODS

Bassindale, R., The distribution of amphipods in the Severn Estuary and Bristol Channel, Jour. Animal Ecol., vol. 11, pp. 13-144, 1942.

Cooper, Chalmer L., Occurrence and stratigraphic distribution of Paleozoic ostracodes, Jour. Paleo., vol. 16, no. 6, pp. 764-776, 1942 (reprinted as report of Investigations, no. 83, State Geol. Surv., Urbana, Ill., 1942)

Goodhart, C. B., The ecology of the Amphipoda in a small estuary in Hampshire, Jour. Animal Ecol., vol. 10, pp. 306-322, 1941.

Harding, J. P., Lower Crustacea, British Museum (Nat. Hist.) British Graham Land Exped. 1934-37, Sci. Repts., vol. 1, pp. 319-322, 1941.

Pennak, Robert W., Ecology of some copepods inhabiting intertidal beaches near Woods Hole, Massachusetts, Ecol., vol. 23, pp. 446-456, 1942.

Watkin, E. Emrys, Observations on the night tidal migrant Crustacea of Kames Bay, Jour. Mar. Biol. Assoc. United Kingdom, vol. 25, pp. 81-96, 1941.

Wells, John W., Supposed color-markings in Ordovician trilobites from Ohio, Amer. Jour. Sci., vol. 240, pp.710-713, 1942.

Wells, Wayne W., Ecological studies on the pinnotherid crabs of Puget Sound, Univ. Washington Pub. Oceanog., vol. 2, pp. 19-50, 1940.

Wilson, Charles B., The copepods of the plankton gathered during the last cruise of the Carnegie, pp. v + 237, Carnegie Inst. Washington Pub. 536, 1942.

VERTEBRATES

Bertram, G. C. L., The biology of the Weddell and crabeater seals with a study of the comparative behavior of the Pinnipedia, British Museum (Nat. Hist.) British Graham Land Exped. 1934-37, Sci. Repts., vol. 1, pp. 1-139, 1940.

David, Lore R., Miocene fishes of Southern California, Geol. Soc. Amer., Spl. Pub. 43, pp. 1-193, 1942.

Gunter, Gordon, Contributions to the natural history of the bottlenose dolphin, Tursiops truncatus (Montague), on the Texas coast, with particular reference to food habits, Jour. Mamm., vol. 23, pp. 267-276, 1942.

Gunter, Gordon, A list of the fishes of the mainland of North and Middle America recorded from both freshwater and sea water, Amer. Mid. Nat., vol. 28, pp. 305-326, 1942.

Naumov, S. P., The seals of the U.S.S.R. The raw material basis of the marine mammal fishery. Series: Economically exploited animals of the U.S.S.R., general editor, N. A. Bibrinskii, Moscou-Leningrad, pp. 105, figs. 18, 1933 (In Russian).

An account of the biology and distribution of the walrus, sea lion, and 10 species of hair seals. One of the best papers on this subject published by the Russians. (Remington Kellogg)

PROBLEMATICAL FOSSILS

Cloud, Preston E., Jr., Notes on stromatolites, Amer. Jour. Sci., vol. 240, pp. 363-379, 1942.

DuBois, E. P., Evidence on the nature of conodonts: Jour. Paleo.,vol. 17, pp. 155-159, 1943.

The classification of conodonts with Annelida is favored by DuBois on the evidence that conodonts occur as pairs or in uniformly arranged groups on slabs of dark Pennsylvanian shales from Illinois. Furthermore, conodonts are associated with problematic segmented impressiors, problematic parapodia, and problematic worm trails. Some assemblages do not exhibit the uniform arrangement and are designated as coprolitic in origin. To counterbalance the evidence presented by associated remains, some admittedly

vertebrate remains such as Lystracanthus spines, Cladodus teeth, and Holmsella scales are found in abundance associated with the conodonts.

The evidence that conodonts are fish teeth on the basis of their calcium phosphate composition is challenged because some worm tubes have been reported to be largely calcium phosphate. Worm tubes are secreted by the ectoderm. Since the "buccal cavity and pharynx are formed by invagination of the embryonic ectoderm and since the annelid jaws are probably physiologic homologs of the ectoderm," it is then probable that some worms are capable of secreting calcium phosphate mandible parts.

Ecologically the typical Pennsylvanian black shale associations include brachiopods, Orbiculoidea, and Lingula, worm trails and burrows, and the vertebrate remains listed above. (Samuel Ellison)

Scott, H. W., Conodont assemblages from the Heath formation, Montana, Jour. Paleo., vol. 16, pp. 293-300, 1942.

Many conodont assemblages are described from the black Heath shales of Montana. The ideal assemblage is described as consisting of paired groups; at least one pair of the platform type such as Polygnathus, Cavusgnathus, or Streptognathodus; at least one pair of the denticulated bar or blade type such as Ozarkodina, Bryantodus, Prioniodus, or Prioniodella; and lastly, four pairs of Hindeodella. Each of the assemblages containing the various paired forms are considered to have come from a single animal. If this is true, it would greatly reduce the number of recognizable genera and species.

The black muds in which these assemblages were laid down are interpreted as having accumulated in waters exceptionally calm and undisturbed. Otherwise the conodont groups would have been dispersed. (Samuel Ellison)

MISCELLANEOUS REPORTS

Dr. Remington Kellogg has submitted the following list of Discovery Reports published in England by the Cambridge University Press. This list supplements the one that appeared in the Report of the Subcommittee on the Ecology of Marine Organisms issued in November 1941.

Anon., . . . Report on the progress of the Discovery Committee's investigations, Discovery Committee, Univ. Cambridge Press, pp. 52, pls. 10, June, 1937.

Dennell, Ralph, On the structure of the photophores of some Decapod Crustacea, vol. 20, pp. 307-382, pls. 24-26, December 1940.

Anon., Station list 1931-1933, vol. 21, pp. 1-226, pls. 4, Feb. 1941.

Hamilton, G. E., A rare porpoise of the South Atlantic, Phocaena dioptrica (Lahille, 1912), vol. 21, pp. 227-234, pls. 5-6, Feb. 1941.

Stephen, A. C., The Echiuridae, Siphunculidae, and Priapulidae collected by the ships of the Discovery Committee during the years 1926 to 1937, vol. 21, pp. 235-260, October, 1941.

Hart, T. John, Phytoplankton periodicity in Antarctic surface waters, vol. 21, pp. 261-356, October, 1942.

Anon, Station list 1933-1935, vol. 22, pp. 1-196, pls. 4, March 1942.

Mackintosh, N. A., The southern stocks of whalebone whales, vol. 22, pp. 197-300, figs. 9, June 1942.

DIATOMS AS FOOD OF OYSTERS

by

Thurlow C. Nelson
Rutgers University

Modern knowledge of the food of the oyster is due mainly to three investigators: Martin '23 who emphasized the importance of nannoplankton formerly overlooked; Savage '25 who showed the importance of diatoms in fattening the English oyster; while Yonge '26 disproved the contention of Danish investigators that Zostera detritus was the main food of the European oyster. Yonge considers lamellibranchs to be "specialized herbivores capable of the extracellular digestion only of starch or glycogen." Yonge emphasized the importance of Martin's findings by showing the very large extent to which digestion in the oyster is intracellular. His conclusion that the oyster is unable to utilize zoöplankton was questioned by Nelson, who in 1921 and in 1933, showed that both in the European and in the American oyster copepods, nauplii, snail veligers, and nematodes are fragmented and dissolved. Nelson '21 demonstrated the importance of diatoms living on the shells of oysters and in this year and again in 1941 and '42 emphasized the outstanding qualities of Skeletonema in building glycogen reserves and superior flavor in oysters. Savage gives chief credit for "fattening" of oysters in English waters to Nitzschiella longissima f. parva. The importance of this and of other littoral diatoms for American and Atlantic Coast oysters was confirmed by Nelson in '34 and '42. The very long or spinous diatoms such as Chaetoceros, Rhizosolenia, and Thalasscothrix were designated in 1942 as "weeds of the sea" since they are eaten in much smaller proportion by the oyster than are the smooth spineless and shorter forms.

That diatoms have long played a major role in the food of lamellibranchs is indicated first by the rapid accumulation of glycogen reserves by the molluscs when diatoms are abundant, and by the demonstration of Berkeley '33 that in Saxidomus the autoxidizable component of the oxidase system of the crystalline style is strongly activated by some substance contained in diatoms while the style extract alone is quite inactive. This would indicate a very long period of association between Saxidomus and the diatoms which comprise its food.

Artificial culturing of diatoms in the laboratory has been carried on for many years while recent efforts to increase the plankton and the fish of fishponds through applications of fertilizer appear to be unusually successful. As yet, however, little is known regarding the factors which make for the abundance or the scarcity of the littoral and pelagic diatoms of brackish waters. Gran '31 showed the importance of soil extract and specifically of iron to growth and reproduction in Skeletonema costatum. This has just been confirmed for Delaware Bay water by Johnstone (unpublished). In this element may lie the explanation of the stimulating effect of heavy run off from the land upon the abundance of this diatom. Experience also shows that a heavy downpour occurring at low tide with exposed

oyster bars and flats usually stimulates the growth of littoral diatoms. The most probable explanation is the Co_2 brought down by the rain from the air.

Experiments have been in progress on the Delaware Bay shore of Cape May County, N.J., to determine the possibility of enriching the surface of an oyster bed and thereby increasing the number of diatoms thereon. Commercial fertilizer, bone meal, soybean and cottonseed meal, fish meal, and iron salts have been mixed with peat, with peat and clay, with and without sand and made into pellets which are then sunbaked. These are hard enough to stand even rough handling without breaking, and when thrown overboard sink quickly to the surface of the oyster bed where they retain their form for at least a month.

Preliminary experiments reveal two difficulties not present in fresh water. Soluble inorganic phosphates are quickly precipitated at the pH 8.4-8.6 of the bay water. When applied in organic form in the various meals, decomposition of the meal causes local depletion of oxygen with deposition of sulphides by the action of sulphate bacteria in sea water. Hydrogen sulphide is deleterious to oysters reducing their rate and extent of water pumping. If abundant and persistent wholesale death of oyster occurs bone meal is the least objectionable on this score but to date has not proven successful.

Simple mixtures of commercial fertilizers and peat will give good diatom growths on the surface of the pellets in the laboratory and in an enclosed basin but to date have failed to do so on the oyster beds. Successful solution of the problem would result in a very large financial return to the oyster growers who frequently are prevented from harvesting thousands of bushels of oysters by the poor quality of the meats. The great abundance of Skeletonema in Delaware Bay in 1940-41 added approximately half a million dollars to the value of the oyster crop from that area in this one season.

It is felt that the facts necessary to a successful solution of this problem probably are known today but that they are widely scattered through the literature or are unpublished. The writer feels the need of expert advice from a number of quarters and eagerly seeks it.

REFERENCES

Berkeley, C. '33. The oxidase and dehydrogenase systems of the crystalline style of Mollusca. Biochem. Jour. 27: 1357-1365.

Gran, H. H. '31. On the conditions for the production of plankton in the sea. Con. Per. Int. p. Lex. d.l. mer. Ext du Rap et Pro-Verb, 75:

Martin, G. W. Food of the oyster. Bot. Gaz. 75: 143-169.

Nelson, T. C. '21. Report N. J. Agr. Expt. Sta. for 1920: 317-349.

_____ '33. On the digestion of animal forms by the oyster. Proc. Soc. Exp. Biol. & Med. 30: 1287-1290.

_____ '34. Report N. J. Agr. Expt. Sta. for 1934: 18-21.

_____ '42. On the role of diatoms in the fattening of oysters. Bull. Oyster Inst. N. America 8, No. 30, 5-8, Washington.

Savage, R. E. '25. The food of the oyster. Fishery Invest. Ser. 2, Vol. 8, No. 1, 1-50. Min. Agr. & Fish. London.

Yonge, C. M. '26. Structure and physiology of the organs of feeding and digestion in Ostrea edulis. Jour. Mar. Biol. Assn. 14: 295-386.

ECOLOGIC RELATIONSHIPS OF LARGER FORAMINIFERA

by

Earl H. Myers
Hopkins Marine Station of
Stanford University
Pacific Grove, California

Many have speculated upon the life activities of the larger Foraminifera but since the largest of these are now extinct, it is necessary that conclusions be based upon the observed activities of smaller species now living in the shallow waters of tropical regions that are related to or resemble those found in older marine sediments. In considering this problem, one might ask: How numerous were these larger Foraminifera, and how widely were they distributed during a geologic period? What was the life span? At what rate did they reproduce? What was the nature of the food? Was growth continuous or discontinuous and why? Were zooxanthellae essential to respiration and the elimination of nitrogenous waste? In this discussion observed activities and preparations of living Foraminifera will be described and methods explained that might contribute to a better understanding of these and other problems.

FOOD

The Foraminifera utilize as food most minute plant and animal organisms and much detrital organic material found both in the water and on the bottom, but are unable to capture any organism capable of vigorous movement. The nature of the food of the species is related to the size and position of the pores and apertures in the test. In most foraminifers having a large aperture, entire organisms of considerable size are ingested. The nature of the food may be readily determined from cytoplasmic inclusions observed in paraffin sections. Tinoporus, Gypsina, and probably many of the larger Foraminifera that were provided with groups of pores but no larger apertures, probably utilized bacteria and other minute soft bodied organisms, or when larger organisms were utilized they were digested within a mass of ectoplasm that collected at one side of the test. These and other large warm water foraminifers when living in an aquarium make no attempt to capture minute arthropods nor have we found the remains of these or other large organisms entangled in the pseudopodia of preserved material although feeding experiments prove that they readily accept and digest by means of ferments in the pseudopodia the soft parts of dead animal organisms. The pseudopodia of Operculina, Heterostegina, Alveolinella, and other relatively large species are as finely attenuated as, and no longer than those of a large Quinqueloculina, and it is somewhat surprising to see the tests of these species moving up the vertical walls of an aquarium by means of such delicate strands of protoplasm. In Heterostegina and Operculina, no food organisms were observed in the cytoplasm as was also the case in Tinoporus and Gypsina, while in Alveolinella and Marginopora minute soft bodied organisms and the

broken frustules of diatoms are common in the cytoplasm contained in the distal chambers. Alveolinella and Marginopora are voracious feeders if we are to judge from the mass of organic detritus that usually covers the apertural face of the tests even in material removed from the sea. The amount of food required by densely populated beds of these larger Foraminifera could, so far as we know, only be produced within the photic zone.

RATE OF GROWTH AND LIFE SPAN

From cultural experiments and statistical data of populations in the sea, it was found that a full day was required to produce a single chamber of Elphidium, Rotalia, and even smaller species of Discorbis, and that from five to seven days of grazing and metabolic activities passed before the next chamber was added. Although the temperature in tropical waters tends to accelerate the rate of metabolic activities, our evidence suggests that the rate of growth in the tropics does not exceed that observed in the spring and early summer in the higher latitudes and is more closely related to the amount of food available than to the temperature of the water. In those species in which the test consists of annular series of chamberlets the rate of growth may be accelerated as was the case in Sorites and Amphisorus. When growth is interrupted due to a shortage of food, as during the winter in the middle and higher latitudes, the few chambers added are short and narrow compared with those formed while food is abundant. From variations in the size of the chambers in an otherwise orderly series it is usually possible to recognize individuals that have survived the winter or have lived for more than one year. In most tropical regions there are two periods each year when food is more abundant as a result of wind induced turbulence, and currents which mix the impoverished surface with deeper nutrient-rich water. Evidence of this was observed in Operculina and other species taken near the western end of the Java Sea near Strait Soenda, but was less evident in material from the central portion of this sea where the food supply is more nearly constant at all times. Large individuals of Operculina often contain a hundred chambers and it is probable that these have lived for at least two years. The life span of Tinoporus must be equally long since only one in many hundreds of living microspheric individuals is provided with brood chambers indicating that they had arrived at the maximum growth stage. Evidence of brood chambers in larger foraminifers are indeed rare.

RATE OF REPRODUCTION

The number of progeny asexually produced by a microspheric foraminifer varies with the size of the individual. Small species including Spirillina, Patellina, and Cornuspira seldom produce more than from 8 to 12 while larger species of Discorbis, Elphidium, Amphistegina, and Calcarina produce as many as 225. The number of progeny asexually produced is limited by the number of masses of protoplasm containing a single nucleus that result when the protoplasm of the microspheric individual undergoes multiple fission. In most species these mononucleate masses approximate in size the proloculum of megalospheric tests except, as in species of Discorbis, where there is

a complete breakdown of the septa between the chambers of the microspheric test during reproduction and the juveniles are provided with two or even three chambers before leaving the parent test, or, as in the Peneroplidae, where the juveniles are provided with a curcumambient chamber and, as in Tinoporus, where the earliest juveniles consist of three unusually large chambers while still retained in the brood chambers in which they are produced. Should one wish to know the probable number of progeny asexually produced by one of the larger species of Foraminifera he would determine the approximate volume of several microspheric tests, and divide this by the approximate volume of the proloculum and the related chamber or chambers. This could be easily accomplished when well preserved tests are available in which the chambers have not become filled with mineral salts by first infiltrating the tests with paraffin and then treating them with acid. After the weight of the paraffin casts has been determined, it would be possible to remove and weigh that portion of the cast representing the primordium.

NUCLEOCYTOPLASMIC RELATIONSHIPS

In many species microspheric tests are larger than the megalospheric. When this is the case megalospheric individuals have but a single nucleus while the microspheric has 40 or more depending upon the species. This however, is not always the case for in Operculina and Heterostegina tests of the two generations are about equal in size and the nuclear relationship is similar to that observed in species in which there is a difference in the size of microspheric and megalospheric individuals. In Tinoporus the two types of individuals are approximately equal in size until immediately prior to reproduction when large brood chambers are added to the microspheric tests. In this species, the nucleus of megalospheric individuals is retained by one of the three large chambers that constitute the juvenarium until immediately prior to gametogenesis. In Marginopora and Alveolinella the tests of both generations contain many hundreds of nuclei, and in the former genus megalospheric individuals reproduce either sexually or asexually. Nucleocytoplasmic relationships similar to those described probably existed in extinct species in which test morphology and the earliest chambers resembled those of recent species.

NATURAL HABITAT

The natural habitat of a foraminifer is often suggested by the morphological characteristics of the test. Since within the intertidal zone only those species that are firmly attached to the substratum or live on reef weed can survive the turbulent surf, one of the poorest places to look for foraminifers is the living portion of a coral reef. The majority of species living in lagoons are relatively small so will receive only passing comment. Tinoporus is found on weed growing immediately below the intertidal zone and is attached to the weed by masses or strands of protoplasm that have a diameter equal to that of the spine from which it arises. Usually there are several points of attachment, and when weed covered with this species are preserved in formalin the foraminifers are

not easily dislodged by shaking the container. Baculogypsina provided with much longer spines are found on weed growing at depths of from 20 to 60 meters, and is often taken on a firm sandy bottom at some distance from patches of weed. Many species of Calcarina are provided with spines but these live on weed in the intertidal zone where there is a moderate surf. Not all species provided with spines live on weed since Rotalia pulchella is found only on the softest mud bottoms, but in this case the spines are exceedingly long and slender and probably serve to keep the test from settling into the mud. Alveolinella and Heterostegina are found on firm sandy mud bottoms and are most numerous near patches of weed where the juveniles may be taken in considerable numbers. Marginopora is usually firmly attached by animal cement and a nest-like mass of organic debris to weeds, dead corals, shells, or similar objects in the shallow water bordering a reef while the smaller species of Sorites and Amphisorus are found on weed growing in the intertidal zone. The large much flattened tests of Operculina are found on the soft mud bottoms to which it is particularly well adapted, while Heterostegina with an equally large test but protruding umbilical mass is better adapted to the firm sand or sandy mud bottom that are its natural substratum.

These observations suggest that most Foraminifera provided with large planospiral, fusiform, or discoidal tests are limited to firm sandy or sandy-mud bottoms within the sublittoral zone at depths that do not exceed that at which photosynthetic organisms thrive and are most numerous in areas adjacent to reefs where coral, calcareous algae, or encrusting bryozoans, or all three are abundant. Strong currents are required to transport these large tests and under these conditions one often finds them mixed with coarse detrital reef material including broken coral or even gravel from previous horizons. Where current action has altered the beds, it seems more likely that the finer sediments have been removed rather than that the tests have been transported.

DENSITY OF POPULATIONS

Sorting due to current action may at times result in considerable deposits of Foraminifera consisting of one or more species. Immediately below the outer reef opposite Sanoer on the Island of Bali in the Netherlands East Indies nearly pure deposits of Tinoporus were observed, which when a pole was thrust into the beds, were found to be at least 30 inches in depth. The sand on some portions of the beach in this region consists of almost a pure deposit of this form and is used to construct walks and roads. Extensive deposits of Operculina were also observed on the Sumatra side of Strait Soenda in which the major portion of the sediments was composed of this one form.

The population per unit area of these species may at times number hundreds or even thousands per square foot and it is somewhat amazing that so many organisms can survive in waters in which the amount of food is presumed to be exceedingly small, although when we recall the amount of animal life represented by a living coral reef, and that the principal source of food to the corals are animal organisms, while the Foraminifera

are omniverous it is somewhat less remarkable. These and other deposits suggest conditions similar to those that must have existed when certain foraminiferal limestones were being formed.

ZOOXANTHELLAE

It has been presumed by some that the production of oxygen through photosynthesis and the utilization of carbon dioxide and nitrogenous waste by zooxanthellae may have contributed to the success of certain larger Foraminifera. However, it would seem that there is a close relationship between the presence of zooxanthellae and test morphology for these symbiotic algae seem to occur only in species having relatively large apertures. Sorites, Marginopora, and Peneroplis often contain so many of these plant cells that they seem to occupy at least as much of the test as the protoplasm of the foraminifer. Zooxanthellae do not occur in Tinoporus, Heterostegina, and Operculina probably because of the small diameter of the pores and apertures when present. In Quinqueloculina and Vertebralina the apertures are large, however, no zooxanthellae are found, for even when ingested by these omniverous feeders they are expelled from the test along with diatom frustules, the cellulose walls of bits of multicellular algae, and the occasional appendages of an arthropod. In those species which harbor zooxanthellae megalospheric juveniles acquire these plant cells as cytoplasmic inclusions at the time the juveniles are produced, while in the microspheric generation they are ingested together with food, since the zoospores or gametes do not contain them.

GEOLOGIC SIGNIFICANCE

Although Tinoporus is exceedingly numerous in certain areas in the Netherlands East Indies facing the Indian Ocean, their distribution is probably limited to a few square miles. Alveolinella, Heterostegina, and Baculogypsina are more widely distributed but they also inhabit a relatively small portion of the Java Sea which has an average depth of only 40 meters. It is presumed that much of the region is one of slow subsidence. Under these conditions a progressive shifting of reef areas and the silting over of what was formerly a firm sand or sandy-mud bottom might greatly extend the apparent range of these and other foraminifers having similar requirements. The larger Foraminifera are used as guides to the age of geologic formations and the biotic conditions that prevailed at the time they were deposited, but in making geologic correlations their usefulness is limited by the fact that the conditions required for their success probably was at no time extensive, compared with that of species typical of softer mud bottoms.

TERTIARY AND CRETACEOUS PALEONTOLOGY OF CALIFORNIA BASED ON FOSSIL FISH REMAINS

by

Lore R. David
California Institute of Technology

Receding and transgressing seas have left a record of fossil fish remains in the Tertiary and late Mesozoic marine sedimentary rocks in the Coast Ranges of California. These formations permit a review of changing fish faunas for a long period of geological time, longer than is usually the case at any one locality. Special attention has been given to these assemblages during the last few years. Profound changes have been noted in fish faunas which are due to the progressing age of the strata in which they occur. Of special interest to students of marine sedimentation are the marked differences in types of assemblages represented in strata of different age; differences evidently caused by changes of environment. Differences in facies, as shown by a study of fossil fish-scales, agree in general with those recorded by students of Foraminifera.

In what follows the distinctive types of fish assemblages that are found in California are briefly reviewed:

The Upper Miocene is the only epoch in the California Tertiary from which large number of fossilized fish skeletons are known. The specimens occur generally in siliceous shales, and it is presumed that volcanism played a role in the preservation of these fossils. Diversified faunas have been described from this epoch, generally of neritic to bathyal environments (see Special Paper 43, of the Geological Society of America).

Except for these faunas, which in many places contain complete skeletons, the fish remains in California strata are represented only by single bones and scales. In some strata scales are distributed in great abundance.

The Upper Miocene is likewise very rich in scale assemblages, especially in its Mohnian stage. Assemblages are in general of neritic facies and forms of a warm-temperate climate are present. The assemblages of the Los Angeles Basin and of the San Joaquin Valley are similar. The same types are usually abundant and are found repeatedly in a given section belonging to this period of time. Bathyal facies are present in places, especially in the uppermost Miocene strata of the Delmontian stage. Deepening of the sea is indicated by greater abundance of the genera Bathylagus, Lampanyctus and Cyclothone. True deep sea types are never found in the Los Angeles Basin; they occur occasionally in the San Joaquin Valley together with other forms, inhabitants of water of lesser depth.

The Lower Miocene is characterized by a great prevalence of abyssal assemblages especially in its lowermost strata, the Zemorrian stage. Differences have been noted among such assemblages; Macrouridae are abundant in places, Berycomorph fishes in others. This stage is also characterized by the appearance of a number of warm-water loving types, as certain Sparidae and Berycomorph fishes.

Eocene fish forms are best preserved in the Upper Eocene and are very abundant in the Kreyenhagen formation of the San Joaquin Valley. Eocene scales are in general distinctly different from those in the Miocene, only a few of the forms known from the lowermost Miocene are found also in the Eocene. The uppermost strata of the Kreyenhagen show in places assemblages of néritic facies of a warm coastal sea. As a rule, the strata of this formation indicate extensive marine conditions of uniform type and of a fairly deep facies. Only a few forms are present and these are found in monotonous repetition in the strata; a genus of the Polymixiidae, inhabitants of medium deep water down to 400 fathoms; a genus of the Exocoetidae, members of which faimly swim pelagically far out into the sea; a salmonoid ? fish of unknown relationships; and occasionally a Bregmacerotid fish, a genus most often found in medium depth. Middle and Lower Eocene strata are usually barren of fish remains.

The oldest faunas thus far studied are available from Upper Cretaceous strata. An abundance of fish remains occur in the Moreno and Panoche formations of the Panoche Creek area, middle Coast Ranges. The great gap known to exist between the Upper Cretaceous fish and the earliest known Tertiary forms is apparent also in California. The California Cretaceous fish are comparable to known Upper Senonian faunas. Different assemblages are present, all of which indicate fairly shallow coastal seas.

The California fish scale assemblages as a whole seem to show a great uniformity in composition over large areas at any one stage. Great diversities may be shown by assemblages that differ in age, as assemblages of different bathymetric facies prevail in different periods. It is evident that physical changes in the environment and in sedimentary conditions must have played an important role in the selection of the fish forms that were preserved. The study of these scale assemblages therefore seems to be of special interest in the study of ecological problems presented by ancient strata. More detailed comparisons of fossil forms and of the ecological conditions under which they might have existed with recent types and habitats might furnish interesting results in solving problems of sedimentation. Such studies would necessitate a much greater comprehension of existing conditions and habitats in oceanic environments than is available today.

- - - - - -